

Initial observations of a population of Mitchell's Rainforest Snail *Thersites mitchellae* Cox 1864

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ABSTRACT

Mitchell's Rainforest Snail *Thersites mitchellae* Cox 1864 is listed as 'endangered' under the NSW Threatened Species Conservation Act 1995, as 'critically endangered' under the Environment Protection and Biodiversity Conservation Act 1999, and is on the IUCN Red List. Over the last 30 years, fewer than 20 live snails have been formally recorded in Museum and National Parks records. From the discovery of shells of the species, and a known habitat at Stotts Island in the Tweed River, it is understood that the species is highly specific in its habitat preference, occurring in 'Lowland Rainforest on Floodplain' and the margins of *Melaleuca quinquenervia* swamps in northern New South Wales, Australia. 'Lowland Rainforests on Floodplain' is itself listed as an endangered community. In this paper an initial description of the behaviour of the first substantial population discovered beyond Stotts Island is described. Like many land snails it was found to be nocturnal and sensitive to light. It appears to be highly sensitive to atmospheric humidity, and while active was mainly found on logs and leaf litter. Suggestions are made for profitable future studies that would provide a better understanding of its behaviour and habitat requirements, and consequently facilitate further discovery of the species and contribute to its conservation.

Key words: *Thersites mitchellae*, Mitchell's Rainforest Snail, land snail, mollusc, behaviour, habitat, *Melaleuca quinquenervia*.

Introduction

Mitchell's Rainforest Snail *Thersites mitchellae* Cox 1864 has been officially protected in New South Wales since 1997, being the first invertebrate listed as 'endangered' under the New South Wales *Threatened Species Conservation Act* 1995 (TSC Act). The species has also been listed as 'critically endangered' under the *Environment Protection and Biodiversity Conservation Act* 1999 (EPBC Act), and is internationally recognized as endangered (category ENC2a) on the IUCN Red List. A recovery plan for the species has been prepared and was approved by the New South Wales government in July 2001 (Murphy 2002). *T. mitchellae* is known to occur in 'Lowland Rainforest on Floodplain' in the New South Wales North Coast Bioregion which itself is listed as an Endangered Ecological Community under the TSC Act.

Thersites mitchellae has a restricted distribution, occurring on the coastal lowlands between Ballina and Banora Point (near Tweed Heads) (Stanisic 2000). The snail is believed to be found in remnant areas of lowland subtropical rainforest and swamp sclerophyll forest with a rainforest understorey. Preferred areas are thought to be alluvial soils with a basaltic influence and on the slightly higher ground around the edges of wetlands with *Archontophoenix cunninghamiana* (Bangalow/Piccabean palm) and *Ficus* spp.

Historical records from the Australian and Queensland Museums suggest that the snail was common in areas such as the Big Scrub rainforests which were previously extensive on the NSW north coast (Stanisic 1998). Although some doubt exists about its tolerance to sandy substrates, the snail has been reported to occur on Pleistocene/Holocene coastal dune systems in swamp areas that contain *Melaleuca quinquenervia*/*Eucalyptus robusta*. These are probably a secondary habitat (Dr John Stanisic, Queensland Museum, pers. comm.).

The main threat to *Thersites mitchellae* is the loss of habitat as a consequence of extensive land clearing (Stanisic 1998; Stanisic 2000). The remaining habitat is relatively small, fragmented, and at risk from development (Murphy 2002). Additional threats that have been identified include: (i) habitat degradation by fire, (ii) exotic weeds, and (iii) predation by the Noisy Pitta, *Pitta versicolor*, and the introduced Black Rat, *Rattus rattus* (Ponder 1997; Sherley *et al.* 1998; Stanisic 2000).

Prior to this study, the largest verified population of *T. mitchellae* was at Stotts Island Nature Reserve in the Tweed River near Murwillumbah. This island is alluvial in origin and the vegetation in which the snail occurs consists of subtropical rainforest characterised by *Heritiera trifoliolatum* (White Booyong) and *Ficus* species (Stanisic 2000). Evidence of several other

populations of the species have been identified, including near Cumbebin Nature Reserve at Byron Bay, although numbers are unknown. Recent population estimates vary between 350 and 500 individuals throughout its entire range (Stanisic pers. comm.), although no verified museum collections or sightings of live individuals have been made since 1999.

There is scant information about the biology and ecology of most Australian terrestrial snails (Ponder 1997) and little knowledge regarding their spatial ecology or population dynamics. Little is known of the biology of *T. mitchellae*, including rates of fecundity, life span and dispersal patterns. The dietary requirements of Australian terrestrial snails are poorly known but may include a range of functional feeding groups (Mason 1970a; Mason 1970b; Colman and Burch 1983; Caldwell 1993). A number of studies have been conducted examining the food preferences of various terrestrial snails (e.g. Lawrey 1980; Fröberg *et al.* 1993; Baur *et al.* 1994). Puslednik (2002) found a strong dietary preference for fungi in two species of Camaenidae in southeastern Australia. *T. mitchellae* is not carnivorous, as evidenced from its radular structure and its activity on warm, humid nights (Stanisic 2000; Murphy 2002), but it is not known if populations are composed of oligophagous individuals or polyphagous individuals with similar food preferences. The nocturnal activity of terrestrial snails in respect to temperature and humidity has been investigated by several researchers, concluding that humidity is of most importance in habitat preference while temperature influences geographical distribution (Abdel-Rehim 1983). The daily and seasonal behavioural activities of *T. mitchellae* are unknown. Previous studies by Bailey (1981) demonstrate that circadian rhythm in terrestrial snails is normally synchronised by dusk, although behaviour is also considered to result from complex interactions with environmental factors, social interactions and cognitive factors (Attia 1981).

Most rainforest snail species in eastern Australia inhabit the litter zone, although juveniles of some Camaenidae are semi-arboreal (Stanisic 1998). Terrestrial snails generally have a bimodal distribution of shell shape resulting in either low or high-spined species (Cowie 1995). It is suggested that shell shape is related to preferred habitat through inclination angle, and that arboreal and burrowing species have relatively high spires, whereas globular and flat-shelled species tend to dwell on the ground surface (Cameron and Cook 1989). Furthermore, Chiba and Davison (2007) argue that there is a strong correlation between litter depth and spire height as a result of local adaptation. Most historical records for *T. mitchellae* do not include habitat information, though notably the species is obtusely trochiform, with a strongly elevated spire, suggesting a preference for burrowing in leaf litter.

A population of *T. mitchellae* was located in January 2009 at the Byron at Byron Resort at Suffolk Park, just south of Cape Byron (Figure 1). The site has had a long history of disturbance, as farm land for the major part of the twentieth century, and in the 1970s becoming a resort called the 'Everglades' in which canoe courses were established. The present resort was built in the early in the present century. The site is immediately inland of an intermittently closed and open lake/lagoon system (ICOLL) which collects water from the nearby basalt-capped escarpment and drains through Tallow Creek to the ocean (Figure 1). The natural vegetation remaining at the site includes a major area of *Melaleuca quinquenervia*-dominated wetland interspersed with areas of littoral rainforest, with many *Archontophoenix cunninghamiana* (Bangalow or Piccabeen palms) (Figure 2).

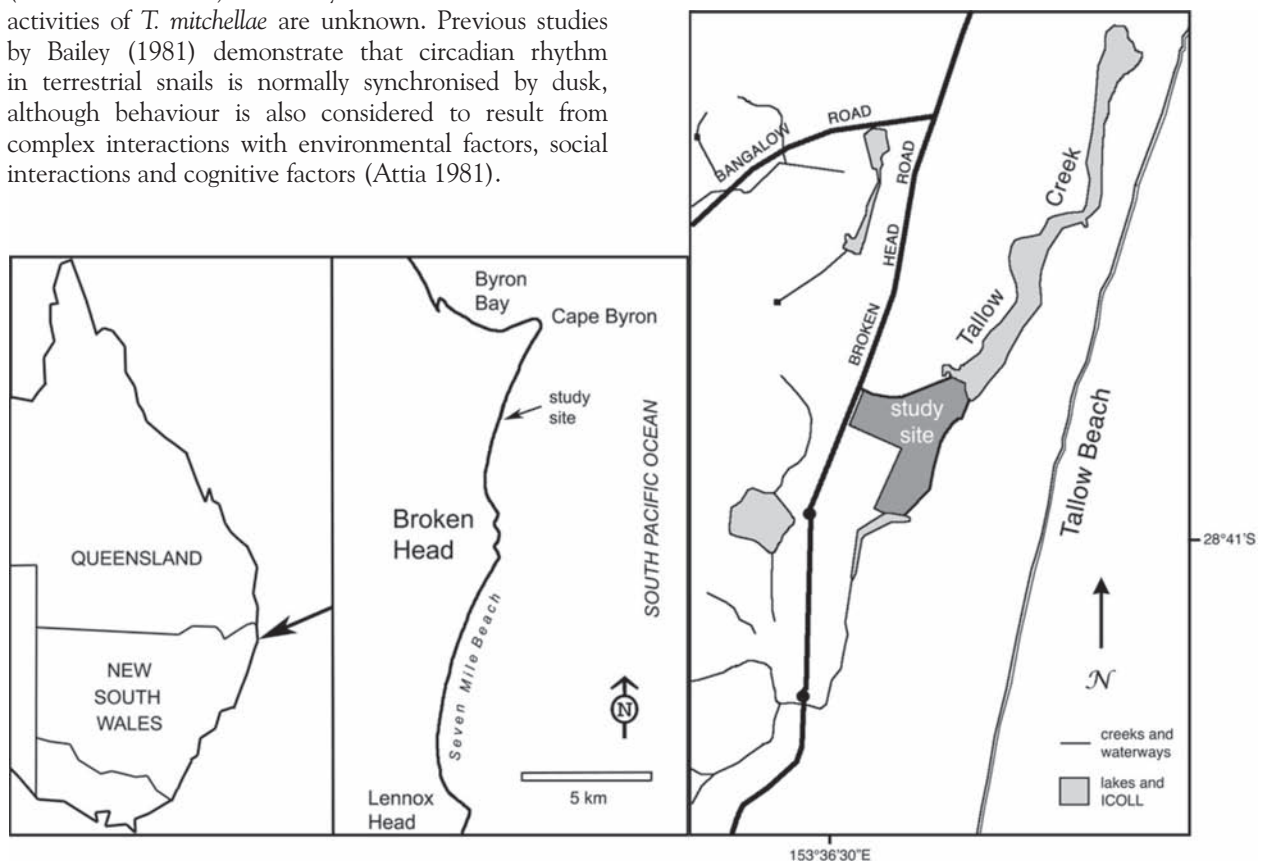


Figure 1. The study site is immediately upstream of the main body of the Tallow Creek ICOLL (intermittently closed and open lake and lagoon). Based on the 1:25,000 topographic map, Byron Bay 9640-4S, 2002.

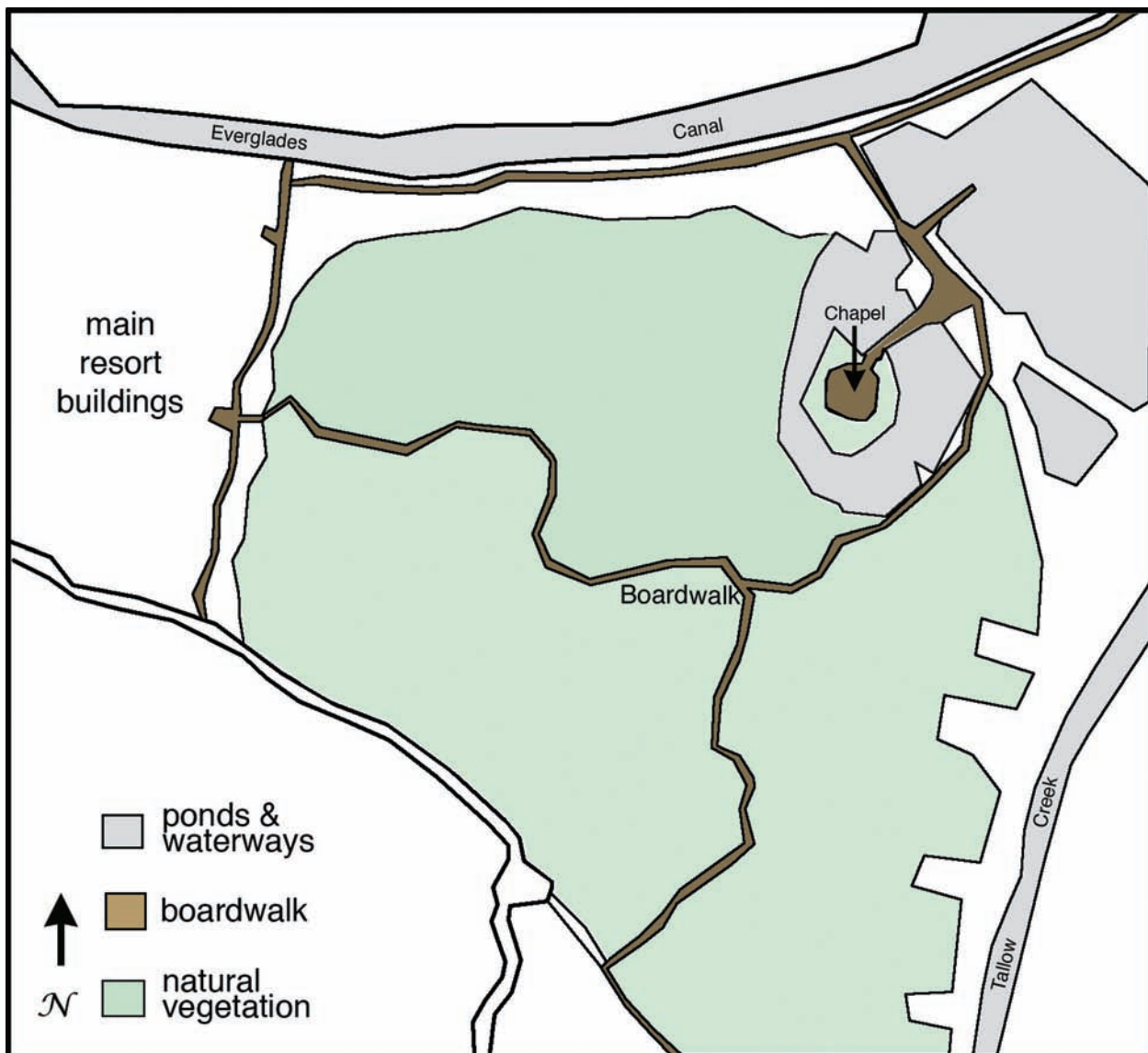


Figure 2. Major features of the Byron at Byron Resort showing the location of the main area of natural vegetation. The Boardwalk, a raised timber walkway on timber supports, surrounds and crosses the area, expanding into a platform at the Chapel site. Guests are confined to the Boardwalk when traversing the site.

The species was reported during site surveys prior to the development of the present resort (Mr Peter Parker, Peter Parker Environmental Consultants Pty Ltd, pers. comm.), and has subsequently been identified during site restoration works (Ms Rosemary Joseph, regenerator, pers. comm.). Observed sites included an 'anvil' with shell evidence, where the Noisy Pitta (*P. versicolor*) has taken individuals to break open their shells and eat them; the boardwalk (a recent man-made structure); and an area in which tree stumps and large logs were stockpiled (the 'log' location).

This study had several aims, namely: (i) to investigate the nocturnal emergence and (ii) habitat use of *T. mitchellae*, and (iii) to examine the main vegetation types in which the snail occurred while active.

Methods

Observations of *T. mitchellae* at the identified locations were conducted over three evenings/nights on 18-19 February 2009, 24-25 February 2009 and 3-4 March 2009.

The area around the chapel (a timber platform similar in structure to the boardwalk) was separated from the linear boardwalk in the observations (Figure 2) resulting in four sites: the anvil, boardwalk, chapel and log sites.

Snail surveys

Repeated, half-hourly, thorough observations were conducted by three people for the duration of the study. The snail was not handled at any time, in order not to influence its activity. The two main locations at the study site, the chapel and boardwalk, were searched over six hours (first night) and seven hours (second and third nights) from 17:00 hours on the first night and 19:00 hours on the subsequent two nights. On the second two nights, the 'log' location (150m² in area) was observed for 2 hours at the end of the evening. The 'anvil' was observed on the first two nights only. The search area was 150 m² for each of the anvil, log and chapel locations (nights one and two), and 200m² for the boardwalk and the third night at the chapel.

During each observation period, the snails could be accurately identified by their shell features and overall size. Photographs of each snail were taken using a digital camera for confirmation of identification within the night. Each snail encountered could therefore be given a unique identity; if it was found again on the same night, a repeat observation was noted. On each snail sighting, its activities at the time of sighting (out of shell, moving, stationary, eating and so on), the habitat in which it was observed, and the broad vegetation type in which it was found, were noted. The snail's response to the activity of the observers (light in particular) was also noted.

The overall meteorological conditions for each night were obtained from the Cape Byron Bureau of Meteorology recording station, located nearby. The occurrence of rain or drizzle was noted at time of sighting.

The data were collated and each observation classified for analysis using the crosstabs option in the Statistical Package for the Social Sciences (SPSS).

Results

One hundred and six observations were made of snails over all three nights, several being repeat observations of the same snail (Figures 3a and b). Snails encountered early in the night were re-encountered up to seven times in proportion to the duration of observation remaining after their initial discovery. During these observations, several features were noted: (i) snail emergence, (ii) the vegetation type in which the snail was active, and (iii) habitat use.

The weather during the three nights was mild, with measurements taken at time of observations being: a largely clear night on 18 February, clear on 24 February, and rain squalls on 3 March (Table 1). Despite the bursts of heavy rain on the third night, the humidity was greatest on the first night, which was also the coolest.

Without accurate identification of individual snails between nights, an estimate of the overall population size was not possible, but a maximum of fifty individual snails were reliably observed on a single night. *T. mitchellae* was found at the anvil, along the linear boardwalk, in the native vegetation around the chapel, around the log, and once on a bitumen track. For the sites that were monitored on all three nights (the boardwalk and chapel), the sightings of snails were low on night 2 (24 February) in comparison to

the other two nights (Figure 4). The most popular locations for *T. mitchellae* appeared to be the chapel and the log site, and snails were observed at these sites consistently throughout the night. During the time observed (2 hours per night over two nights), the log site was the most populous.



Figure 3a. The adult *Thersites mitchellae* (Family Camaenidae Subfamily Camaeninae) at the site. Two yellow bands per whorl are evident, as is considerable shell damage. The shell was lighter and more olive in colour than previously described (Murphy 2002; Stanisic 1998). The fine recurved radial lines noted by Stanisic (1998) are clearly visible.



Figure 3b. Individuals of *T. mitchellae* are obtusely trochiform, with a strongly elevated spire. The eyes are carried on the upper set of tentacles whilst the lower set of tentacles, the olfactory organs, are retracted in this individual.

Table 1: Micrometeorological data taken at the time of observation of each snail. Evening temperature and humidity data were obtained from the Byron Headland Bureau of Meteorology station, and the rainfall conditions were obtained from systematic notes (clear, drizzle or rain) taken at each snail observation throughout the night.

Observation	Temperature °C	Humidity (%)	Rainfall (% of observations)		
			clear	drizzle	heavy rain
18.2.09	22.13 ± 0.05	96.64 ± 0.25	63	36	
24-25.2.09	24.60 ± 0.03	65.43 ± 0.34	100		
3-4.3.09	24.52 ± 0.06	82.06 ± 0.60	63	2	35

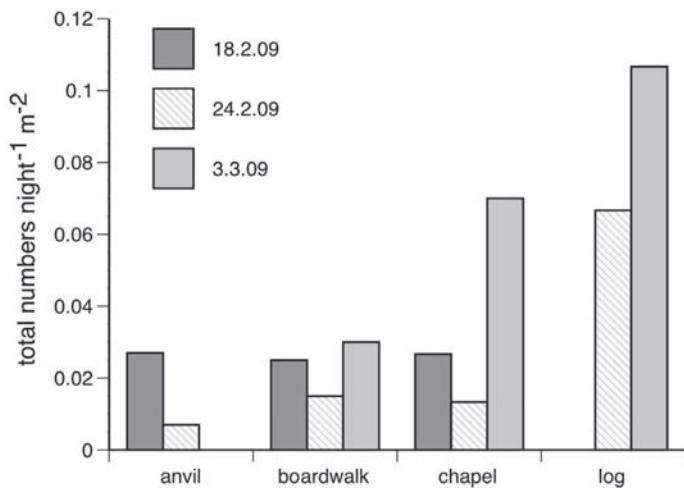


Figure 4. Total numbers of snails per unit area located at each site on each observation night. The sites are as follows: the anvil site is an area where the Noisy Pitta takes the snails to open them and eat them, leaving the shell behind; the boardwalk site is a linear strip of area on either side of the boardwalk; the chapel site is the area immediately around the raised wooden platform around the chapel; and the log site is an area around a pile of discarded logs from past building activity at the site.

Snail emergence per night

At the chapel and boardwalk, snails emerged at last light, slowly at first, and then in greater numbers, until at around 11pm, all of the snails encountered had appeared (Figure 5). It was difficult to determine whence they emerged (i.e. their day time refugia), but it was noted that several were sheltering under the boardwalk during the day, and some seemed to shelter in leaf litter or logs (Figure 6), and some appeared to shelter in leaf litter. There appeared to be several phases of snail emergence: (i) emerging at the beginning of the evening, (ii) emerging in the middle (9pm) of the evening, and (iii) emerging late, around 10pm. At the boardwalk, two cohorts were identified, with an indication of a later, third, group, but numbers were generally low at this location.

Vegetation types used

There were four main vegetation types in which the snail occurred. As much of the vegetation of the site is an interface between melaleuca swamp and rainforest vegetation, variations were identified according to: (a) presence of ferns, (b) proximity to swamp, and (c) age class (i) mature to old growth *Archontophoenix*-dominated palm forest with scattered *Melaleuca quinquenervia*, notably with an abundance of scattered logs, and (ii) (littoral) rainforest

Figure 5. Emergence of snails at the chapel, boardwalk (bdwalk) and log sites on 18 February (night 1), 24-25 February (night 2) and 3-4 March (night 3) 2009. Observations by three people on each occasion began at 17:00 hours on the first night at the boardwalk and the chapel sites, and 19:00 hours on the subsequent two nights. On the second two nights the 'log' location was observed for 2 hours from midnight. The total search area was 150 m² for the log location and on nights one and two at the chapel, and 200m² for the Boardwalk and the third night at the chapel.

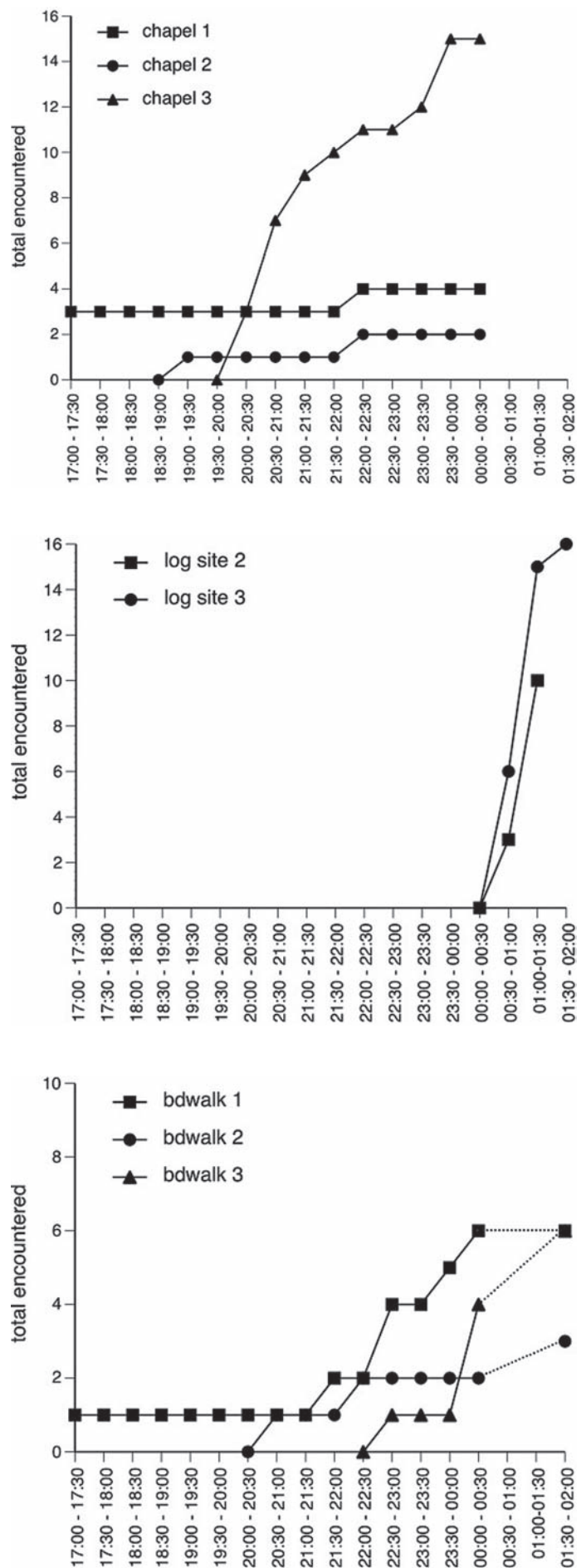




Figure 6. On the few occasions when *Thersites mitchellae* was observed during daylight hours, it was often seen upside-down, in this instance inside a rotting log. The deep reddish-chestnut to black colour noted as characteristic of the species (Murphy 2002) is evident in this specimen. Snails also appeared to shelter in leaf litter during the day.

without *Melaleuca*, including one occurrence on a bitumen track in the rainforest. According to the observational data, these vegetation types occurred differently from location to location (Pearson's Chi-square $p = 0.000$) (Table 2).

Habitat use

The habitats in which snails were observed during each evening were classified as: (i) timber and logs, (ii) leaf litter, (iii) fern fronds and sticks, (iv) tree trunks, (v) rock, concrete and gravel, (vi) soil, and (vii) palm fronds. 'Timber' included any man-made structures such as fence posts and the boardwalk itself. As might be expected, these habitats were found variously at the different sites (Table 3). There was a correlation between location and the type of habitat used, which indicates the availability of that habitat at the site (not presented in this paper), with the chapel having an almost even representational use of litter and timber, while snail use at the log site was, as the title indicated, predominantly of logs (Pearson's Chi-Square $p = 0.008$).

The minor categories were amalgamated (soil and gravel, rock and concrete were joined, as were palm and fern fronds and sticks), showing that the most used habitat overall was 'timber and log' (mainly the boardwalk itself or other such posts) (42%) and secondarily on 'leaf litter' (38%) (Figures 7, 8a and 8b).

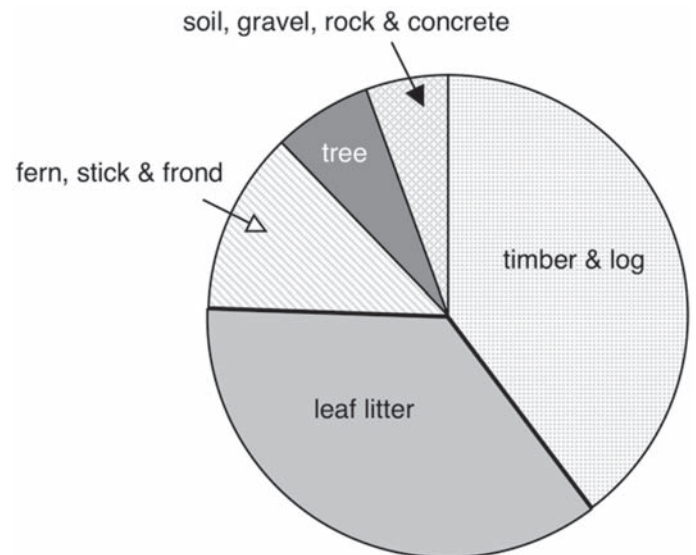


Figure 7. Proportional use of habitat by *Thersites mitchellae* observed at each of the five locations at the study site. These figures report the use of habitat when the snail was observed throughout the evening, and do not represent retreat sites. The majority of time was spent either on or in leaf litter and on log (fallen) or timber (structures) surfaces.

Activity patterns

At the very beginning of the evening, the snails were sometimes observed in their shells, but it was difficult to locate them when they were inactive. Once active, they were more visible, and therefore most observations of snails were while moving over the substrates listed under 'habitat'. On six occasions, snails were observed eating the fruiting-bodies of small fungi growing on some of the logs (Figure 9). Several times individuals were observed upside down under the boardwalk, or vertical on a tree, boardwalk post, or stout stick. There was a common reaction to light, with individuals retreating into their shell when torches were shone, or sheltering their heads under leaf litter, for example. Snails were startled by sudden movement, such as footsteps on the boardwalk (an uncommon occurrence at night), by coins being placed next to them for photographs, or by the sudden rustle of leaf litter.

Table 2. Use by snails of different vegetation types according to location. These data were noted at the time of each snail observation.

Location	Melaleuca/rainforest interface			
	(a) with ferns	(b) proximal to swamp	(c) old growth	rainforest
chapel	39	13	0	0
boardwalk	1	17	5	0
anvil	0	0	4	0
log	0	0	3	23
track	0	0	1	0

Table 3. Use by snails of various habitat types according to location, obtained from the habitat and locational classification used at each snail observation.

Location	Timber and logs	Leaf litter	Fern fronds and sticks	Tree trunks	Rock, concrete and gravel	Soil	Palm fronds
chapel	20	22	4	4	1	1	0
boardwalk	9	7	2	1	1	1	1
anvil	1	2	0	1	1	0	0
log	12	7	6	1	0	0	0
track	0	0	0	0	1	0	0

**Figure 8a.** The most used habitat overall was 'timber and log' (42%) and secondarily 'leaf litter' (38%). This adult snail was observed moving between the two.**Figure 8b.** It appears that one of the strongest climatic influences on the species is atmospheric humidity, and activity increased on humid nights as is shown here. The adults have a thickened, reflected lip, with a thin lighter line on the dorsal midline.**Figure 9.** *T. mitchellae* was observed eating small fungal fruiting bodies. The snail brought the caps to 'ground' level to access them, leaving the stalks behind, which returned to the upright position as seen to the left of the photograph.

Discussion

The observations reported in this paper are an initial description of the behaviour of *T. mitchellae*, and represent one of the few studies of behaviour in any species of terrestrial snails in Australia. The results presented here, whilst descriptive, indicate several factors which will assist in the better understanding of species behaviour, habitat use, and hence likely occurrence.

The snails are confirmed to be nocturnal, and the sensitivity to light of some individuals suggests this is probably a photophobic response. Whilst there is some evidence of visually guided behaviour in terrestrial snails (Hermann 1968; Gal *et al.* 2004) it is considered that distant objects are detected through chemical senses (Emery 1992; Chase 2001). There was a common

reaction to light, with individuals retreating into their shell, although the degree of light sensitivity appeared to vary between individuals, possibly related to age and development. Visual resolution in land snails is understood to be generally poor and the eye merely responds to light and shadow, regulating reproductive function and facilitating circadian rhythms (Sokolove and McCrone 1978). Observations of *T. mitchellae* appear to be consistent with existing understanding of terrestrial snails in general in that circadian rhythm is normally synchronised by dusk (Bailey 1981). Although light/dark cycles synchronise daily activity, abiotic factors such as temperature, humidity, and rainfall affect behavioural activities (Attia 2004).

Thersites mitchellae prefers timber, logs and leaf litter while active. This is consistent with previous observations of the snail's occurrence around logs and on tree trunks (Murphy 2002) although the evidence has been slight until now. Most rainforest snail species in eastern Australia inhabit the litter zone, although juveniles of some Camaenidae are semi-arboreal (Stanisic 1998). The notion that *T. mitchellae* is semi-arboreal is supported by its preference for timber and logs, as the category 'timber' includes the boardwalk posts. The obtusely trochiform shell shape allows for equal distribution of weight, consistent with the suggestion of Cameron and Cook (1989), that shell shape is related to preferred habitat inclination angle.

The preference of *T. mitchellae* for logs and dependence on litter also suggests a preference for mature forest, or forest with a high proportion of such debris on the ground. One of the characteristics of over-mature or old growth forest is a high proportion of logs and coarse woody debris on the ground (Burgman 1996). The main indicators of old growth in rainforest include (i) a comparatively high proportion of rotting logs and other coarse woody debris, (ii) late-successional stage species, and (iii) epiphytes including strangler figs. Some of these features can be

the product of disturbance, and in the study location, the presence of logs is mimicked by the log pile and board walk. This, among other factors, may contribute to the large population present.

Despite no replication of this result, the notable drop in numbers when the humidity fell below 80% indicates that one of the strongest climatic influences on the species is atmospheric humidity. This is consistent with Abdel-Rehim (1983): activity increases with increased humidity which may also play an important part in the substantial numbers present at the site.

These data suggest several avenues of further investigation:

1. observations throughout the light/dark cycle to investigate daily behavioural activities;
2. longer term study to investigate differences in temperature and humidity with regard to nocturnal activities;
3. comparison of species characteristics, population variables and site parameters of different populations/sites;
4. mark-recapture sampling accompanied by habitat information to:
 - determine specific features of habitat correlated with snail occurrence (e.g. pH, calcium, fungus, log density/type, litter depth, elevation, soil moisture content),
 - compare/contrast adult and juvenile individuals with respect to habitat preference,
 - determine longevity and growth rates, and
 - determine refugia during day time and aestivation.

Only through such studies can the required information for the conservation management of the species be properly determined.

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References

- abdel-Rehim, A.H. 1983. The effects of temperature and humidity on the nocturnal activity of different shell colour morphs of the land snail *Arianta arbustorum*. *Biological Journal of the Linnean Society* 20: 385-395.
- Attia, J. 2004. Behavioural rhythms of land snails in the field. *Biological Rhythm Research* 35: 35-41.
- Bailey, S.E.R. 1981. Circannual and circadian rhythms in the snail *Helix aspersa* Müller and the photoperiodic control of annual activity and reproduction. *Journal of Comparative Physiology* 142: 89-94.
- Baur, A., Baur, B. and Fröberg, L. 1994. Herbivory on calcicolous lichens: different food preferences and growth rates in two co-existing land snails. *Oecologia* 98: 313-319.
- Burgman, M.A. 1996. Characterisation and delineation of the eucalypt old-growth forest estate in Australia: a review. *Forest Ecology and Management* 83: 149-161.
- Caldwell, R.S. 1993. Macroinvertebrates and their relationship to coarse woody debris: with special reference to land snails RS. Pp. 49-65 in Biodiversity and Coarse Woody Debris in Southern Forests: Proceedings of the Workshop on Coarse Woody Debris in Southern Forests: Effects on Biodiversity, edited by D. A. Crossley and J. W. McMinn. USDA Forest Service, Ashville, NC, USA.
- Cameron, R.A.D. and Cook, L.M. 1989. Shell size and shape in Madeiran land snails: do niches remain unfilled? *Biological Journal of the Linnean Society* 36: 79-96.

- Chase, R. 2001. Sensory Organs and the nervous system. Pp. 179-211 in *The Biology of Terrestrial Molluscs*, edited by G. M. Barker. CABI Publishing, New York.
- Chiba, S. and Davison, A. 2007. Shell shape and habitat use in the North-west Pacific land snail *Mandarina polita* from Hahajima, Ogasawara: current adaptation or ghost of species past? *Biological Journal of the Linnean Society* 91: 149-159.
- Colman, P. and Burch, J. 1983. The Fauna: Molluscs. Rainforests: Special Issue, Vol.2 No. 1
- Cowie, R.H. 1995. Variation in species diversity and shell shape in Hawaiian land snails: in situ speciation and ecological relationships. *Evolution* 49: 1191-1202.
- Emery, D.G. 1992. Fine structure of olfactory epithelia of gastropod molluscs. *Microscopy Research and Technique* 22: 307-324.
- Fröberg, L., Baur, A. and Baur, B. 1993. Differential herbivore damage to calcicolous lichens by snails. *Lichenologist* 25: 83-95.
- Gal, J., Bobkova, M.V., Zhuvov, V.V., Shepeleva, I.P. and Meyer-Rochow, V.B. 2004. Fixed focal length optics in pulmonate snails (Mollusca, Gastropoda): squaring phylogenetic background and ecophysiological needs (II). *Invertebrate Biology* 123(2): 116-127.
- Hermann, H.T. 1968. Optic guidance of locomotor behaviour in the land snail *Otala lactea*. *Vision Research* 8: 601-612.
- Lawrey, J.D. 1989. Lichen secondary compounds: evidence for a correspondence between antiherbivore and antimicrobial function. *The Bryologist* 92: 326-328.
- Mason, C.F. 1970a. Food, feeding rates and assimilation in woodland snails. *Oecologia* 4: 358-378.
- Mason, C.F. 1970b. Snail populations, beech litter production and the role of snails in litter decomposition. *Oecologia* 5: 215-239.
- Murphy, M.J. 2002. Mollusc conservation and the New South Wales *Threatened Species Conservation Act* 1995: the recovery program for Mitchell's Rainforest Snail *Thersites mitchellae*. *Australian Zoologist* 32: 1-11.
- Puslednik, L. 2002. Dietary preferences of two species of Meridolum (Camaenidae: Eupulmonata: Mollusca) in southeastern Australia. *Molluscan Research* 22: 17-22.
- Ponder, W.F. 1997. Conservation status, threats and habitat requirements of Australian terrestrial and freshwater Mollusca. *Memoires of the Museum of Victoria* 56: 421-430.
- Sherley, G.H., Stringer, I.A.N., Parrish, G.R. and Flux, I. 1998. Demography of two landsnail populations (*Placostylus ambagiosus*, Pulmonata: Bulimulidae) in relation to predator control in the far north of New Zealand. *Biological Conservation* 84: 83-88.
- Sokolove P.G. and McCrone E.J. 1978. Reproductive maturation in the slug, *Limax maximus*, and the effects of artificial photoperiod. *Journal of Comparative Physiology* 125: 317-325.
- Stanisic, J. 1998. Survey for Land Snail *Thersites mitchellae* in northern New South Wales. Unpublished report prepared for the NSW National Parks and Wildlife Service.
- Stanisic, J. 2000. Survey for Land Snail *Thersites mitchellae* in northern New South Wales III. Investigation of Stotts Island Locality. Unpublished report prepared for the NSW National Parks and Wildlife Service.